KEYWORDS: ***Rock art – Production – Replication – Ethnography – Scientific mindset***

FUTURE DIRECTION OF ROCK ART RESEARCH: AN INDIAN PERSPECTIVE

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Abstract. In human history, rock art has been one of the most powerful means of communication, created and developed by early humans on rock surfaces. A global phenomenon, this important human creation has widely survived the vagaries of time. Rock art is also considered to constitute exograms, i.e. memory traces stored outside the human brain on the natural surface of rock. Therefore, it is an essential source for understanding the perceived reality of its authors, which can form the basis for comprehending and appreciating the cognitive, technological and cultural development of early humans through time and space. To achieve this goal, we need scientific study of the essential properties of rock art and understand the processes of its production, survival and damage, i.e. its preproduction processes, production processes and postproduction processes. The first two stages can be understood to some extent by the replication of rock art and the ethnographical study of the creative traditions of indigenous communities. In contrast, the third stage involves pure scientific pursuits of multiple disciplines, including the taphonomy of the site and rock art. The conceptual aspects of all these processes of rock art research are discussed in this paper, emphasising an Indian perspective.

Rationale

The present paper is in continuation of the author's article 'Change of mindset: the need for developing scientific approaches to rock art studies' (Kumar 2021a). It explained how the European model of archaeology retarded the scientific study of rock art worldwide for centuries. Archaeology is incapable of defining emic cultures reliably. It merely classifies material residues of human populations and then makes the untestable assumption that those taxonomic constructs define distinctive peoples or cultural traditions. This used to be taken so far that the perceived movement of technological traits or behaviour patterns was equated with the migration of actual peoples in the absence of any other evidence (Bednarik 2007: 11). The major rock art sites usually consist of cumulative records of successive traditions, and without identifying these traditions individually, archaeology can only create false concepts of traditions. This practice is comparable to excavating the tools of many traditions and then lumping them all together and defining them as a single cultural assemblage. This is the most anti-archaeological way one could treat the layers of an excavation, yet in rock art, this is precisely how many archaeologists have treated the evidence. For instance, many such cumulative site inventories in Australia are described as 'Panaramitee style', even though they consist of many chronologically discrete components (Bednarik 2007: 11). A better-known example is that of the rich rock art of Lascaux Cave in France which consists of a cumulative record spanning Palaeolithic and post-Palaeolithic traditions of at least 10 000 years (Bahn 1994), yet for over half a century it has been held up as a paragon of one single tradition.

For many Indian archaeologists, accepting cupules as a form of rock art is still very difficult. Bednarik published the cupules on Chief's Rock (in Auditorium Cave, Bhimbetka) and their significance as some of the earliest petroglyphs which might be associated with an Acheulian tradition in 1993 (Bednarik 1993, 1996). Nevertheless, the dossier for Bhimbetka rock art heritage submitted to UNESCO by the Archaeological Survey of India does not mention the cupules, the earliest rock art in the Auditorium Cave (Ray and Ramnathan 2002). For Indian archaeologists considered experts in Stone Age archaeology, it took 25 years to accept the cupules on Chief's Rock as rock art. However, their significance is yet to be accepted, and the requisite care for their protection is lacking even today. If archaeology defines its traditions of rock art in this haphazard manner and then bases all kinds of secondary hypotheses on such fallacious data (e.g. that another corpus of rock art must be the same 'age' as that of rock art of Lascaux or, in the case of India, that of Bhimbetka, because it comprises stylistically similar elements), then these invented traditions are probably misleading constructs

and can only lead to further errors (Kumar 2000–01; Bednarik 2007: 11–12). The main focus of archaeology in rock art study has been on observing forms and attempting to determine their antiquity and meaning. Rock art study aims to obtain reliable empirical evidence about its nature and production, investigate the cognitive, intellectual and cultural world of the past and present societies involved in its creation and use, and ultimately, perhaps, determine how our species acquired its very concepts of reality. Thus, the ultimate research potential of rock art is not even closely connected with archaeology.

This alternative rationale was promoted by the International Federation of Rock Art Organisations (IFRAO), established at the first global rock art conference at Darwin in Australia in 1988. Under the umbrella of IFRAO, the collective efforts of scholars and scientists from different countries with a scientific mindset have been changing the shape of the rock art discipline (Bednarik 2007; Kumar 2021a). Today, the needed changes are far from complete. However, it has already become adequately clear that the progress made in the discipline in the last fifteen years of the 20th century and in the early 21st century exceeds in magnitude that of the previous 200 years (Bednarik 2007: 12; Kumar 2021a). Some scholars in India are trying to follow the same path (Kumar 1995; Kumar et al. 2005; Bednarik et al. 2005; Bednarik and Kumar 2012; Kumar and Krishna 2014; Kumar 2021a). The present paper discusses some conceptual approaches in this direction.

Future direction of rock art research

Therefore, the future direction of rock art research needs scientific approaches and the mindset required for these. Scientific study of rock art means whatever we postulate can be tested by anyone at any time. To comprehend rock art scientifically, we need to focus on understanding the processes and circumstances involved in rock art production and those of its survival.

The most important question that can be asked in our discipline is: how can the origins of human constructs of reality be studied through palaeoart? This goes right to the heart of the epistemology of science. Because of the primitive nature of our work with this body of evidence, such insights may not occur in our lifetimes or this century. Perhaps in a few centuries from now? That must not deter us from moving in the right direction by asking such fundamental questions. However, we shall need to learn to walk before trying to run. At present, we are only crawling because of our breathtaking ignorance resulting from generations of using a mindset foisted upon rock art discipline by archaeology (e.g. of creating futile taxonomies of perceived entities such as types, styles, meanings, iconographic identifications, cultural affiliations, behaviours). Part of the mindset we need to acquire involves recognising how ignorant we are about palaeoart. This academic humility is essential to the mindset required (R. G. Bednarik, pers. comm. 15 April 2020; Kumar 2021a).

The origins of human constructs of reality could be understood by examining the physical remains of the processes that produced rock art, particularly early expressions of symbolism and the factors responsible for its survival and damage. Forensic science can help us greatly in this direction. We have to study a rock art site like a forensic scientist observes a crime site. However, we also have to keep in mind our limitations to comprehend the realities of early man, which were quite different from ours. Only the objective study of rock art can help us discover how humans developed their ontologies and epistemology. It will be the most crucial pursuit in a science serving our species because it would illuminate how the conceptual constructs humans have perceived as realities came into being (Bednarik 2007: 2; Kumar 2021a). Therefore, understanding rock art in time and space needs serious efforts with a scientific mindset and holistic approach.

Essential components of rock art study

Therefore, rock art study would, among other strategies, engender the following essential components (Kumar 2021a, modified and improved):

1. Study of the geology, geomorphology, geochemistry and palaeoenvironment of the site and the region under study. Rock art sites form part of the natural environment, modified by the authors of rock art. Rock art can only be studied by considering the rock, its properties and the processes affecting it. Understanding the physical and chemical properties of rock is essential for understanding the taphonomy (selective survival) of rock art (Bednarik 1994) and the cognitive abilities involved in its production (Bednarik 2016; Kumar 2021a).
2. Rock art survival is directly proportional to the hardness of the rock and its level of physical protection. Besides, rock art produced by a reductive technique survives better than that created by an additive technique. These aspects need careful consideration.
3. The effects of different climatic factors and the weathering processes they engender at the rock surface and the rock art need to be understood in-depth. They form a chronological framework into which rock art can be placed. It will involve the detailed study of exfoliation of the rock surface, accretions deposited on rock art and their chemical analysis, then finding the possibility of scientific dating of rock art. Understanding the environment of the rock art site can also help in using the direct methods of rock art dating. Studying the exfoliation and accretion processes is essential for understanding the results of direct dating of rock art by analysing the accretions and placing them in the proper context (Kumar 2015: 48–57, comments on AMS ^{14}C dating of accretion deposit on cupules in Daraki-Chattan cave).
4. Differentiation between anthropogenic and natural

markings on rock and portable objects is essential in studying palaeoart. It involves carefully observing the object under consideration and a detailed understanding of the vast range of non-anthropogenic rock markings (Bednarik 2007: 15–36). It also involves understanding the processes by which some natural markings have been modified over time which could be misunderstood as rock art or palaeoart.

5. Observation of the rock art, rock art site and its surrounds must be conducted in the way a forensic scientist observes a site of crime. Every site underwent multiple processes that affected the rock surface and rock art, such as exfoliation, weathering of the surface and paint, salt accretion and patina formation, and effects of heat and lightning. Understanding the markings on rock and the tools used for the production of rock art, especially the petroglyphs, not only helps in determining the cognitive development of its authors but also the antiquity of rock art.
6. The major rock art sites have been the dynamic centres of cultural activities through time. Therefore, such sites often consist of cumulative records of successive traditions. We must identify these episodes by thoroughly studying the superimpositions, implements and techniques used, archaeological material and taphonomic observations, at a particular site and region (Kumar et al. 2021a, 2021b).
7. Studying the tangible and intangible processes responsible for producing rock art is necessary. It involves understanding the conceptualisation of the ideas in the form of a composition and strategy to execute it in a two-dimensional form on the natural rock surface. A detailed ethnographic study of the creative traditions of traditional communities that practice rock art production in the region, where possible, can help us to some extent in this direction (Hridayshri et al. 2021a, 2021b; Krishna et al. 2021; Kumar et al. 2021c).
8. Replication of the process of rock art production helps us in many ways, for example, by determining the strategy involved, the proper tools and equipment used, the precision and concentration needed, involvement required to produce the composition. If paint is used, its processing and preparation techniques used and the method and technique of its application are also investigated (Kumar and Krishna 2014; Bednarik and Montelle 2016; Hridayshri et al. 2021a, 2021b; Krishna et al. 2021; Kumar et al. 2021c).
9. Excavations at and in the associated area of a rock art site, if it has suitable and adequate sediments, can help establish the site's chronological cultural sequence and palaeoenvironment. It can also yield pigments, hammerstones and other artefacts used to produce rock art, and even exfoliated slabs bearing rock art as in the case of Daraki-Chattan excavation (Bednarik et al. 2005; Kumar et al. 2005). However, one must have clear objectives, the proper experience of excavating a rock art site and its understanding and, above all, the involvement of scientists to execute scientific work at the site and in the laboratory. Besides, one must have sufficient funds to carry out the project.
10. Rock art dating is an essential aspect of rock art study. Direct dating of rock art involves several sophisticated methods such as AMS ^{14}C dating, U/Th dating, amino acid racemisation, OSL analysis, lichenometry, microerosion analysis, nanostratigraphy and analysis of patina (see *http://www.ifrao.com/rock-art-dating/* for summary and references). These techniques have yielded mixed results in terms of reliability and feasibility. The more precise the result, the more complicated and unreliable the method, while simple methods such as the microerosion dating method provide comparatively less precise but more reliable results, without interference with rock art. It requires petroglyphs to be in an open environment, and the rock should include quartz and feldspar crystals in its constituent minerals. Rocks with high erosion rates can be tried for macroerosion dating (Bednarik 2007: 136). It requires the preparation of a calibration graph from monuments of known ages made of laterite blocks, and the rock must be exposed to precipitation.
11. Scientific work at a rock art site includes considering how we can effectively conserve and manage the site (Bednarik 2007; Kumar 2021a).

Understanding the processes

The processes of rock art production involve:

1. Preproduction processes,
2. Production processes, and
3. Postproduction processes.

Each step can be investigated in detail. The first two steps are closely associated, hence can best be understood to some extent through replication processes and ethnographical study of the creative traditions of the traditional communities still practising production of rock art in the study area, where possible. The third step involves various multidisciplinary studies, including the taphonomy of rock art. However, we must keep in mind that whatever we postulate should be testable propositions at any time, as this forms the guiding principle of all rock art research.

1. Preproduction processes

The region's physical conditions, topography, climate, flora and fauna, and available natural resources play crucial roles in developing cultural traditions and ritual practices to sustain life and development through time and space. Therefore, to comprehend the preproduction processes of rock art, we have to understand the physical conditions and lithology of the site under study, the topography of the region, the natural environment and climate at the time the rock

art was produced, flora and fauna, available natural resources, the habits of the present communities living in it, the ritual and ceremonies they are following and practices accompanied with them (Hridayshri et al. 2021b). It is difficult to comprehend past practices at present; however, studying the processes of the creative traditions and accompanying rituals of the traditional communities living in the study area can help us to some extent.

To further understand the details of rock art production, we must follow the principles and techniques of forensic science. Suppose the rock art is in the form of petroglyphs (rock art produced by reductive technique); in that case, one should detect the hammerstones and other equipment used for its production, understand the nature and hardness of the rock and technique(s) employed (Bednarik 1998, 2016; Kumar and Krishna 2014; Bednarik and Montelle 2016). If the rock art is in the form of rock paintings (pictograms made by applying pigment or other material), we have to understand the material used in making the rock paintings and its source in the region. Understanding the structure of pigments employed in rock art production requires using portable XRD and XRF machines and field microscopy by skilled experts, analysing the so-obtained data in laboratories. We must understand the nature and behaviour of the particular pigment under study. Haematite, a common iron oxide compound (Fe_2O_3), in its pure condition, used to be of dark red or dark brown colour and heavy and hard in nature, while ochre is a coloured earth, hence is comparatively light and softer than haematite. That is why obtaining colour from haematite is a more laborious task compared to that from ochre. Therefore, the selection of pigments, especially haematite in early paintings in Chaturbhujnath Nala, indicates the knowledge of the minerals and their characteristics and the cognitive development of their authors (Geetanjali et al. 2021; Hridayshri et al. 2021a, 2021b; Kumar 2021b; Kumar et al. 2021c; Ram Krishna et al. 2021). It will help us understand the authors' abilities to identify a pigment of particular characteristics and nature, its selection, the quality of the efforts made, and the amount of labour applied to execute a particular rock art composition.

2. Production processes

2a. Replication of rock art

For understanding the production processes, replication of rock art plays a very important role which is evident from our experiments to replicate different kinds of cupules of Daraki-Chattan Cave (DC), a Palaeolithic cupule site on hard quartzite rock. We also tried to replicate early rock paintings of Chaturbhujnath Nala. Both sites are in Chambal valley in the Bhanpura region, district Mandsaur in Madhya Pradesh, India. The cupule replication at DC enlightened us that the production of each cupule on hard quartzite rock (hardness ~7 on Mohs scale) by direct percussion technique is arduous work for two to three days, requiring nearly 30 000 strokes for producing a medium-sized cupule. It involves conceptualising an idea and its execution at a particular place on the vertical surface of the hard quartzite rock. It requires a lot of planning, dedication and concentration. Some sort of music could have accompanied it, its rhythm coinciding with the hammer strokes (Kumar and Krishna 2014). The replication of the deep cupules on a very soft limestone in Australia by Bednarik and Montelle (2016) indicates a different strategy and technique. Some of the cupules on hard rock show the marks of metal implements used to produce them. They were made with metal tools using the indirect percussion technique (Bednarik 2016).

The replication of the rock art of Chaturbhujnath Nala showed that rock painting production also needs conceptualisation of an idea from the perceived reality and its execution in the form of a 2D composition. It also requires the selection of a suitable site and spots to execute it, collection of the required pigments, their processing to provide enough colour of desired tone and of proper density and viscosity, making suitable kinds of brushes from the available natural resources and execution as per conceived ideas and planning. We also felt that all these processes and hard work required well-coordinated and enthusiastic teamwork and must have been executed in a congenial environment and climate. Therefore, rock art production appears to be teamwork associated with socio-cultural activities (Geetanjali et al. 2021; Hridayshri et al. 2021a, 2021b; Kumar 2021b; Kumar et al. 2021c; Ram Krishna et al. 2021). This is the subjective observation we made while replicating the rock paintings of Chaturbhujnath Nala. However, further replicative studies are needed to understand the processes of rock art production properly.

2b. Ethnographical study of the creative traditions

An ethnographic study of the communities practising rock art traditions and having relations with the rock art sites/complexes and their environment can help to have an idea, to some extent, about the epistemology of rock art research (Smith et al. 2021). Ethnographic renderings of the Yanyuwa Country's rock art in Australia consider life a multi-dimensional world of ancestral beings, places, events, descendants and responsibilities, ultimately allowing us to argue the central existence of Indigenous ontologies. However, this kind of insight should not be used to support already constituted disciplinary understandings (Bradley et al. 2021). Inscriptions associated with rock art traditions, e.g. in Saudi Arabia, China and other countries, let their producers communicate their thoughts, concerns, priorities and desires to us (Bednarik 2021). They can also throw some light on the beliefs held and the sacred character of the site.

The rock art site should not be considered an isolated feature in the landscape; rather, it should be treated as an integral part of the natural and cultural environment of the region under study, as shown by the study of Nawarla Gabarnmang, a large rock art

site in Arnhem Land of northern Australia (Gunn et al. 2021), or in Chaturbhujnath Nala, a magnificent rock art site in Chambal Valley, India (Kumar 2022). India has a unique tradition of *Sanatan dharm*a (eternal code of conduct and duties), including its understanding of cosmology, life values, and behaviour deeply integrated with nature and the universe. It supposedly has its roots in the Stone Age cultures, having its reflections in rock art (Abhimanyu et al. 2019), transformed into the tribal and folk art of the early pastoral and agro-pastoral communities, then to cave art of Buddhist, Brahmanic and Jain cults in the Historic period. Some of the traditional communities still practise rock art traditions and rituals in the rockshelters (Elwin 1951; Pradhan 2001; Dubey-Pathak and Clottes 2017: 195–234; Kumar's observation in the rockshelters of Bhabua in Kaimur district of southwest Bihar 2001, Bad-Pathrin and Khambeshwr in Manikpur-Chitrakoot region in Uttar Pradesh in 2001; Pawar 2013). Within the Dreaming ontology of the Yanyuwa, very little rock art is seen to be the work of human beings; instead, these images are actual presences of certain spiritual entities. For the Yanyuwa men and women who understand and have experienced the Country associated with the images, their knowledge is a dialectical order whereby meaning is by the internal logic of discussion, ideas and opinions (Bradley et al. 2021). However, we should remember that ethnographic narrations can be inadequate and contribute to false understandings of cultures by the academic hegemony (Bednarik 2021).

In the light of the above discussion, it appears that careful study of the life of *Adivasis* (Indian aborigines), specifically those of the forest-dwelling or forest-dependent communities, their creative traditions, rituals and practices and above all their spirit to enjoy them in the physical and natural environment can form a good tool to look into the spirit of life of the authors of rock art — of course, up to some extent only. The best way to understand it is to live with them as an integral part of their community and, if possible, as a family member for many years. It may provide some insight into the life and philosophy of that community under study in a particular environment and can help, in a limited way, to understand the cause and effect of rock art production. Therefore, for understanding the first two stages of rock art production, the ethnographical study of the creative traditions and rituals of the traditional communities can be significant, besides the forensic study of the rock art site, its rock art and the replication work (Kumar and Bhatt 2008; Bednarik 2010; Hridayshri et al. 2021a, 2021b; Kumar et al. 2021c, 2021d).

3. Postproduction processes

Every site underwent multiple processes which affected the rock and rock art, such as exfoliation, weathering of the surface and paint, deposition of salt accretions and the formation of patina or kinetic energy metamorphosis (KEM) products on petroglyph surfaces (Bednarik 2016, 2019), effects of heat and lightning. The scientific study of these postproduction phenomena can help us to establish a chronology of the rock art at a site under study and many other aspects involved in the survival of rock art. In the case of petroglyphs, understanding the markings on rock and the tools (stone or metal) used for its production, the technique employed, such as percussion or abrasion, helps determine the cognitive and technological development of its authors, and also the antiquity of the rock art.

The major rock art sites had been the dynamic centres of cultural activities through time, which resulted in superimpositions. These activities might have also left traces in the form of artefacts and objects employed or favoured spots used. Effects of animal and human interference must also be observed. Therefore, the rock art site and its surroundings must be conducted in the way a forensic scientist observes an activity area. If necessary, adequate excavation of the sediments at the rock art site and their scientific analysis can help us a lot, as discussed above (Kumar 2015, 2022; Kumar et al. 2021c).

Besides, rock art research has adopted several new methods, all contributed by scientific disciplines, within the last few years. They include a wide range of physical and chemical analyses of rock art-related materials, such as identifying inclusions in paint residues and mineral accretions, ranging from fibres to pollen and graphite crystals. Much of this work is directed at questions of antiquity, but numerous other issues also attract attention now. The nano-stratigraphy of paints and mineral accretions has shown how rock art sequences can be studied scientifically rather than by archaeological intuition. Numerous approaches are being developed in the ever-crucial question of the age of rock art because postproduction processes are related to rock art age. Field microscopy of rock art has been developed for several purposes, including microerosion dating (Bednarik 2007; Kumar 2007, 2022; Kumar and Pradhan 2008; Kumar et al. 2021a, 2021b).

Concluding remarks

The study of preproduction and production processes involved in rock art creation and the postproduction processes the site and rock art have undergone can provide an insight (of course of limited nature) into the dynamic process of the cultural activities the site has undergone. It can also throw light, up to some extent, on the cognitive, technological and cultural development of its authors. However, there is no readymade path to be followed to understand the conceptual ideas and processes involved in rock art production. This challenge cannot be met at an individual level. We must make collective efforts in this direction. It leads us to the conclusion that, for the scientific study of rock art, we must incorporate many scientific disciplines and innovate many new systems to improve our understanding. Besides, it

needs a scientific mindset which must be developed and inculcated with serious efforts. If we could study rock art objectively (which we may not be able to at present), we might discover how humans developed their ontologies. It will be the most crucial pursuit in a science serving our species because it would illuminate how our species acquired its very concepts of reality and thus became the dominant species on the planet Earth (Bednarik 2007; Kumar 2021a). We may obtain answers to some questions rather than to others. The latter will give direction to further research in rock art science. Therefore, to proceed further in the field of rock art research, we need to adopt the epistemology of rock art science and understand its processes. Our studies need to be based on testable propositions.

Acknowledgments

I am very thankful to the three *RAR* referees for their thoughtful comments on improving the quality of the paper. My thanks are also due to Dr Ram Krishna, Dr Mohana R., Ms Neelam Singh and Dr Himanshu Shekhar, who provided their inputs from young scholars' points of view.

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RAR 40-1425